Adaptation and Survival of early PhD students in the Paleozoic era at the University of Sydney

Gillian P. Courtice[1], Jane F. Thompson[2] and Eric van Beurden[3]

[1] Curlew Biological Services, PO Box 67 Pacific Palms NSW 2428,
[2] The Canberra Hospital, PO Box 11 Woden ACT 2606,
[3] Health Promotion Unit, Population Health Planning & Performance Directorate, North Coast Area Health Service PO Box 498 Lismore NSW 2480

ABSTRACT

Gordon's first postgraduate students emerged at the end of his Devonian period, moving into the Carboniferous with the emergence of amphibian studies. This era was marked by extensive frogging expeditions, when *Litoria aurea* was thick on the ground and *Litoria flavipunctata* called in the New England swamps. Water holding frogs were unceremoniously dug up from the receding rainforests. Early reptilian studies by students were overtaken at the beginning of the Gordon Mesozoic in a massive adaptive radiation, into crocodiles, flying, radio-telemetry, termites, kangaroos, some of the best adapted lasting for eons. Wonderful outback odysseys marked the early era and the diverse environment laid the foundation for emergence of the young and their survival into the Quaternary and the age of man.

Key words: University of Sydney, Gordon Grigg, PhD students, vertebrate research.

Introduction – the Devonian period

Gordon Grigg joined the Zoology Department of the University of Sydney in 1968 as a Queen Elizabeth II Fellow, a prestigious post-doctoral fellowship funded by the Australian Research Council and reserved for students of the highest calibre (Appendix 1, photo 1). As an honours student at the University of Queensland, he had studied aspects of respiration of the Queensland lungfish, *Neoceratodus forsteri*, which was followed by work for his PhD at the University of Oregon, USA on seasonal changes in blood oxygen affinity in a freshwater catfish, supervised by Professor Robert Morris. On arrival at The University of Sydney, it seemed logical to pursue his interest in fish, and he joined up with the fish physiologist, Geoff Satchell. Gordon spent the two years of this post-doctoral fellowship investigating gill function in Port Jackson sharks.

Thus Gordon's early research career was firmly based in the study of fish, which was recognised by the invitation to write a book chapter on respiratory properties of blood of fish for the 'Chemical Zoology' series of volumes (Grigg 1974).

Gordon's scientific interests, however, did not remain with fish. It seemed that, like the evolution of the vertebrates, Gordon had established dominance in the Devonian period, and at the University of Sydney he was given the opportunity to 'evolve' his interests to more modern forms. This 'Devonian period' was marked by 12 scientific publications relating to fish between 1965 and 1970 (Table 1, Figure 1).

We, as his first three PhD students, shared ancient times at the University of Sydney with this common ancestor at the end of his Devonian period, through the Carboniferous and into the Triassic (Figure 1). Gordon's interests continued to evolve with the vertebrates through this Paleozoic era, into the Mesozoic era, and by the 1980s, he was establishing himself in the Cenozoic. Only in more recent times has he shown developing interests in the modern forms of placental mammals (Figure 2). Thus, his working life has been an exploration of the vertebrates, following their evolutionary path, and following the accompanying development of their physiological systems, and how these systems have changed and adapted to the available habitat and conditions. This paper expands on the period of time in Gordon's scientific life in Sydney, where he was occupied in the Paleozoic era, and then launching himself into the Mesozoic era. It is written from the perspective of his first three PhD students, and is neither a complete account, nor a totally balanced one. Our apologies are extended to exacting paleontologists, who will quibble about our rather loose associations between groups of modern animals and the geologic period in which their ancestors may have been dominant on the earth.

The Carboniferous period

One of us (Gill) joined Gordon's lab in 1972 as an honours student to participate in the move into what might be called the 'Carboniferous period' where amphibians became the focus. This period was stimulated by a technical officer in the Department of Zoology at the time, John Barker, who had a deep knowledge and long term interest in amphibians (Plate 2). We embarked on a study of the group of Bell Frogs in south eastern Australia which, in 1972, consisted of four subspecies of *Litoria aurea*, collectively referred to as the *Litoria aurea* complex. The academic result of this year was a revision of this complex into three separate species, *Litoria aurea, L. raniformis* and a new species from the New England tableland, *L. flavipunctata* (Courtice and Grigg 1975). The wider 'by-catch' was extensive exploration of every dam, swamp, river and 'wet place' in NSW and Victoria, a host of recordings of frog calls, and a keen eye for species specific

Theme edition of Australian Zoologist "*Ecology meets Physiology*", a Gordon Grigg festschrift, edited by Lyn Beard, Daniel Lunney, Hamish McCallum and Craig Franklin. Australian Zoologist Vol 35 (2) 2010.

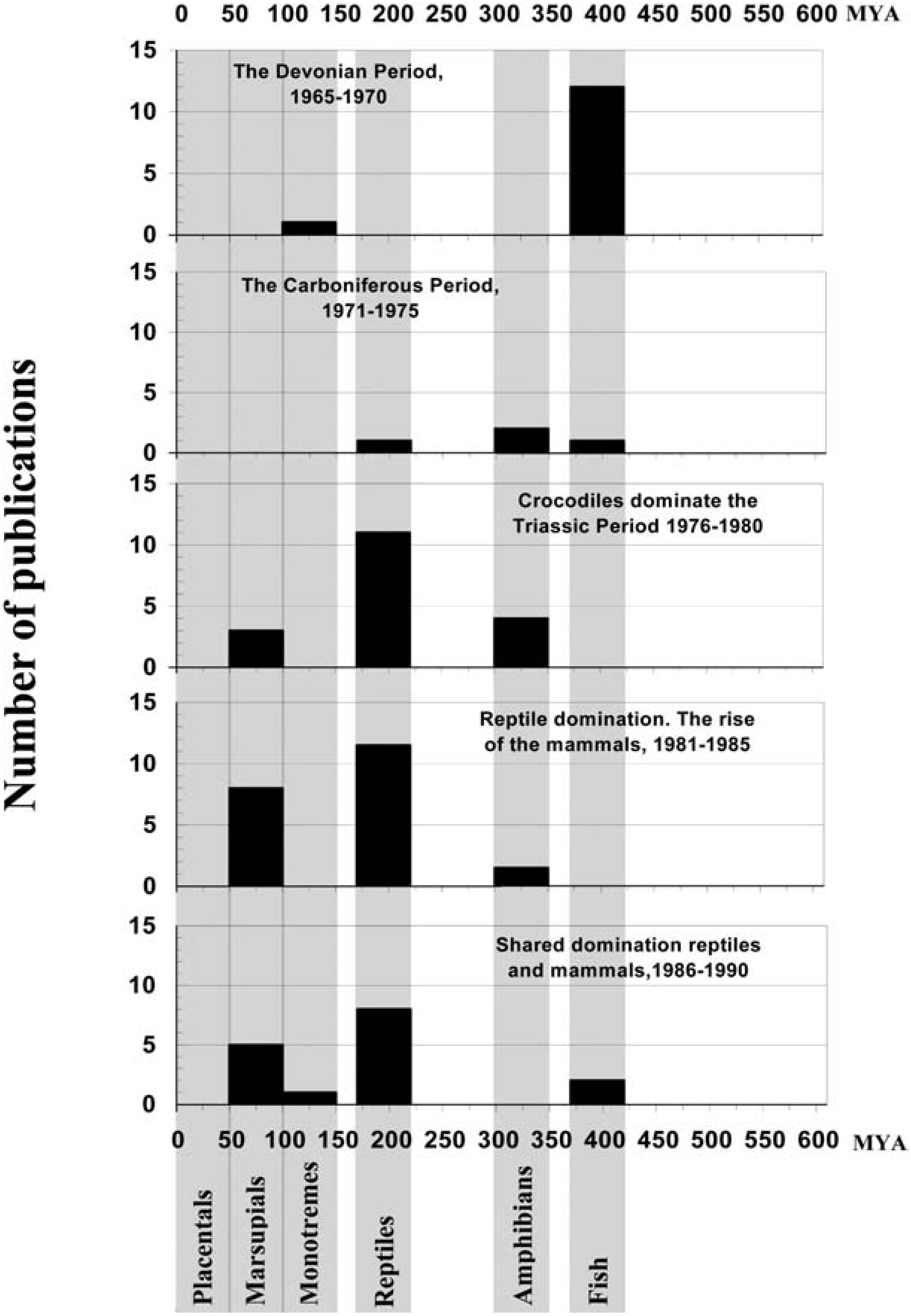


Figure 1. Number of scientific publications by Gordon Grigg prior to and during his tenure at the University of Sydney, as presented in Table 1. Each publication is attributed to a vertebrate group according to its subject matter. Publications attributed to each vertebrate group are plotted on a geologic time scale according to when their ancestors first appeared and/or dominated the earth. There is a trend towards the left (more modern) with time. MYA = million years ago.

Table 1. Number of scientific publications (full papers) by Gordon Grigg from 1965 to 2005. Each publication has been attributed to a vertebrate group according to its subject matter. Publications designated Miscellaneous include 3 on termite mounds, 3 on methods, 2 on evolution, 1 on wildlife research and 1 on emus.

Year of Publication	Topic of publication by vertebrate group						
	Fish	Amphibians	Reptiles	Monotremes	Marsupials	Placental Mammals	Miscell-aneous
1965-70	12			1			
1971-75	1	2	1				1
1976-80		4	11		3		2
1981-85		1.5	11.5		8		
1986-90	2		8	1	5		2
1991-95	3	2	9	7	5	1	1
1996-2000		1	14	4	10	1	1
2001-05	1		6	4	5	3	3

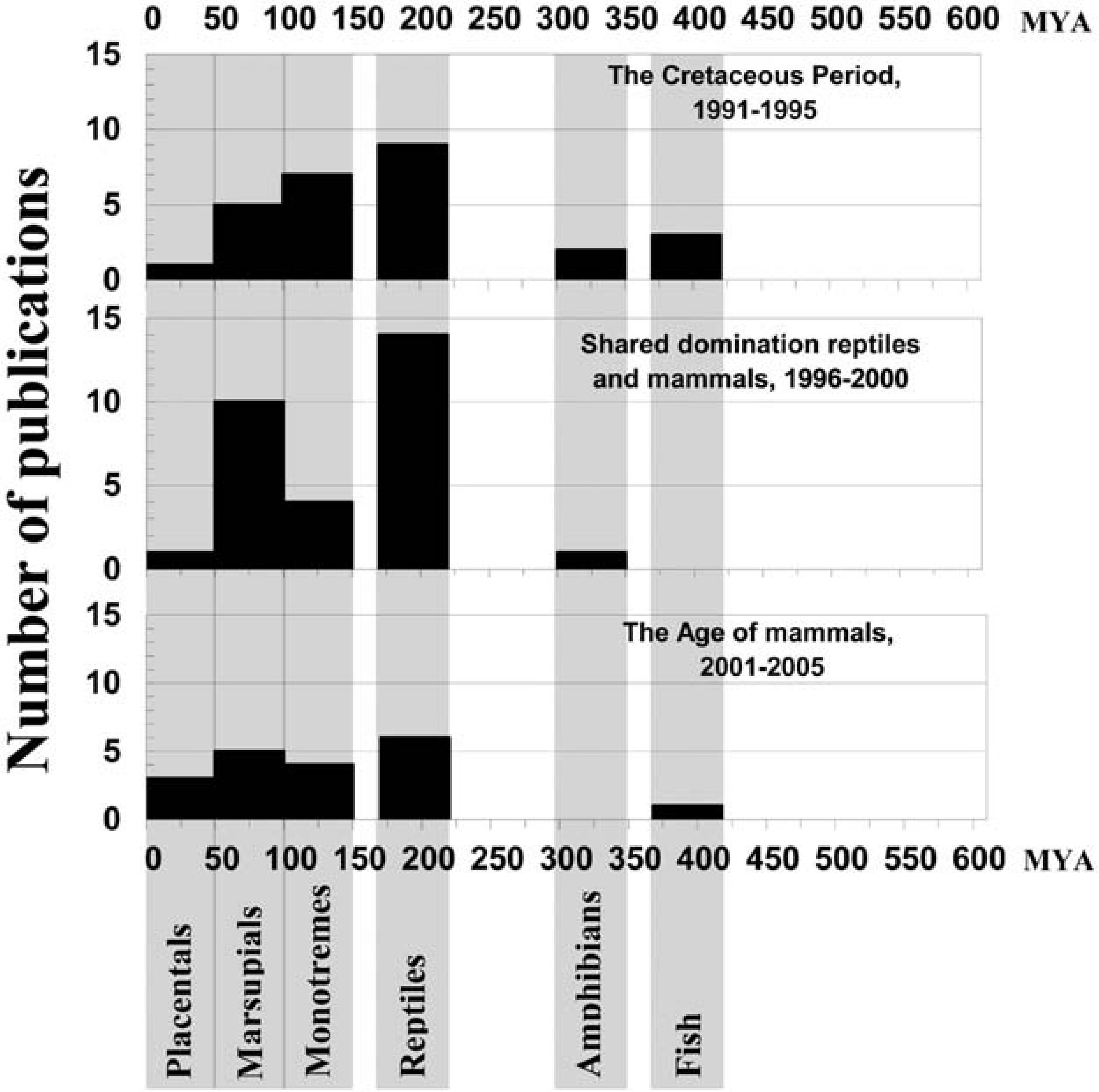


Figure 2. Number of scientific publications by Gordon Grigg from 1991 to 2005 during his tenure at the University of Queensland, as presented in Table 1. Each publication is attributed to a vertebrate group according to its subject matter. Publications attributed to each vertebrate group are plotted on a geologic time scale according to when their ancestors first appeared and/or dominated the earth. The monotremes become significant, and the first sign of placental mammals can be seen. MYA = million years ago.

habitat (Plate 3). Gordon and John produced a tape of frog calls for public distribution (Grigg and Barker 1973) and went on to later produce the first Field Guide to Australian Frogs (Barker and Grigg 1977), which was Gordon's seminal contribution to the Carboniferous period. This book was revised and updated nearly 20 years later (Barker, Grigg and Tyler 1995) and remains an invaluable reference in Australian amphibian biology today.

The early 1970s truly was the 'Age of Amphibians' where frogs were abundant along the east coast of Australia, when urban sprawl had not bulldozed the hundreds of small pockets of breeding habitat, before the decline in amphibians world wide had begun (Halliday and Heyer 1997) and where Bell Frogs were so abundant there was no thought that they might become endangered or extinct. However, geological history tells us that all things become extinct in time and, since 1972, *L. flavipunctata* is presumed extinct, as well as synonomised with *L. castanea* (Cogger *et al.* 1983, Thomson *et al.* 1996) and the distributions of *L. aurea* and *L. raniformis* have shrunk significantly (Mahony 1999).

The Carboniferous period was marked also by the commencement in 1974 of Eric van Beurden's PhD investigations on the Water-holding frog, *Cyclorana platycephalus*. These remarkable frogs avoid the hot dry conditions of Australia's arid regions by spending long periods underground between rains. Their physiological strategies for survival under such conditions, and their immediate ability to breed should heavy rains unexpectedly fall were the subject of much discussion between us all. Not knowing quite how he was going to find these frogs, especially if the three years of his PhD happened to fall between rain events, Eric and Gillian set off for Macquarie Marshes in Gillian's VW Beetle in bright sunshine (Plate 4). Someone was looking after us, (or had Gordon had a word with the gods?) for the first night it poured and poured with rain. We drove every back road, slipped and slid through every mud pile, but we saw more desert frogs that night than is one's privilege to see in a lifetime. From that trip alone, Eric was able to select sites that he returned to in dry periods over the next three years and reliably dug up specimens of *C. platycephalus* as required.

Eric was able to show that *C. platycephalus* enters a state of dormancy while sealed within their clay burrow chambers during dry periods (van Beurden 1980). This enables larger individuals to survive for up to seven years on their fat reserves if water stored in their bladder can be sufficiently replenished and/or diluted from surrounding soil after intermittent rains. In addition, these frogs have an opportunistic breeding strategy, such that at any time that sufficient rain falls, at least some females in any population have mature gametes to create viable breeding ponds (van Beurden 1977, 1979, 1982, 1984).

To appease the paleontologists, it should be noted that Gordon did publish, during this period, a paper on fossilised labyrinthodont footprints (Pepperell and Grigg 1974), a true Carboniferous amphibian!

This age was remarkable too for Gordon's leadership in undertaking remarkable outback odysseys. Not only was every piece of frog habitat explored along the east coast, and in inland NSW, but in 1973, Gordon encouraged his students to join a mammoth expedition to the Simpson Desert, organised by Peter Wong from Sydney Technical College. Ostensibly the task was to search for the Night Parrot (*Pezoporus occidentalis*), which had not been sighted reliably since 1912 (Boles *et al.* 1994). Eric and Gill were to search for desert frogs and reptiles, Gordon was interested in the frogs and termite mounds, others were recruited for their ornithological expertise, 4-wheel driving expertise or just general enthusiasm (Plates 5,6). It is interesting to note that while we were unsuccessful in our search for the Night Parrot, it has been found in more recent years, not far from where we travelled (Garnett *et al.* 1993; Boles *et al.* 1994).

Similarly, in this era, a group of academics from the Zoology Department, their families, students and technicians set off for Mootwingee, NW of Broken Hill one Easter, once again led by Gordon (Plate 7).

The Triassic and Jurassic periods – reptilian domination

Gordon did not languish too long in the swamps of the Carboniferous period, and undertook what could only be described as a spectacular Mesozoic adaptive radiation. He developed an interest in crocodiles, and formed an association with Professor Harry Messel, which afforded him the opportunity to learn to fly, to be involved in early radiotelemetry, to establish his interest in the Northern Territory, and to include those northern magnetic termite mounds in his plethora of interests. In early 1972, in the same year that Gill did an honours project on frogs, Jennifer Alchin undertook an honours year also, supervised by Gordon. Jenny studied cardiovascular responses to heating and cooling in freshwater crocodiles, reflecting this early interest in crocodilian thermal physiology. This study became Gordon's first publication on a crocodile (Grigg and Alchin, 1976).

Gordon encouraged his other two PhD students (Jane and Gill) to embark on projects on lizards, which were to complement his own Mesozoic interests. Jane investigated placentation in the Water Skink, (then *Sphenomorphous quoyii*, now *Eulamprus quoyii*) (Thompson 1977), interested in how much the mother had to input to the developing embryos in this viviparous skink. While she showed a net transport of some substances into the embryos across the placenta (Thompson 1977, 1981, 1982), the ultimate test came when she hatched a young lizard *in vitro* (Plate 8), showing that these embryos in fact were equipped with all the nutrients they needed to complete their development.

Gill studied the adaptations to diving of Water Dragons, *Physignathus lesueurii* (Courtice 1978, 1981a,b), and became interested in the stimuli that precipitated the end of the dive. She provided evidence for airway chemoreceptors and carotid artery chemoreceptors in lizards which had not been demonstrated previously (Courtice 1980), and mapped cardiovascular changes in response to blood chemical properties (Courtice 1981c, 1985).

There was great debate at the time as to the validity of data accumulated from restrained animals, especially with respect to diving bradycardia and associated cardiovascular changes, which resulted in two different types of dives being recorded in the Water Dragons, depending on their level of restraint and 'fright'. Gordon was always a great believer in matching data from the laboratory with that from the field, and subsequent studies on diving in crocodiles with John Wright involved free dives in both the laboratory and the field, substantiating the difference in responses (Wright 1985; Wright *et al.* 1992).

For Gordon, just as reptiles dominated the earth for some 200 million years, so too did crocodiles then dominate his interests and later work for a long time. From the first publication on crocodiles (Grigg and Alchin 1976), Gordon went on to publish more than 45 papers on crocodilian biology (Table 1). Janet Taylor (1977) completed her Masters thesis in 1977 on the foods and feeding habits of sub-adult *Crocodylus porosus*, and Laurie Taplin (1983) and David Kirshner (1985) studied osmoregulation and buoyancy respectively in crocodiles for their PhD theses. Much of the osmoregulation study was done in the field in the Northern Territory, and it led to Laurie Taplin finding and describing salt glands on the tongues of crocodiles, laying to rest a long standing argument among scientists at the time as to if and where salt water crocodiles excreted excess salt (Taplin and Grigg 1981).

During this period of reptilian domination, Gordon served two terms as President of the Australian Society of Herpetologists, and a period as president of the Royal Zoological Society of NSW from 1974-1979. Both these societies sponsored the Australasian Herpetological Conference, held at the University of Sydney in August 1984, organised by Harry Ehmann, Gordon and Rick Shine. The proceedings were published in a volume which contained a remarkable array of original herpetology, which remains a valuable resource today (Grigg *et al.* 1985).

The Australian Society of Herpetologists became the forum at which all the students of that era met, presented their material, however preliminary or complete their findings, and interacted with all the Australian academics interested in frogs and reptiles. It was a small group, meetings attracting about 25-30 participants, and historically had met at University campuses or at the Australian Museum. It was in large part due to Gordon's pioneering spirit that it was agreed that the meeting in 1975 was to be held at a remote homestead NW of Tibooburra NSW, to allow for field observations of a remote area to complement the academic presentations. Gordon agreed to be convenor. As the time drew closer, we three students realised that Gordon was in the Northern Territory with his beloved crocodiles, and was due to return only just before the appointed date. As all good PhD students would do, we sent out notices, called for abstracts, ordered food, liaised with people at Tibooburra, filled up a huge trailer with food, beer, projectors, screens, collecting equipment, bedding etc and set off days before. At Olive Downs, we set up the kitchen, beds, meeting rooms, fired up the boiler for the hot water and greeted the participants. Gordon flew in, landing on the airstrip at Olive Downs in time for the first session (Plate 9)! Although at this meeting in 1975, it was recognised that meetings in remote locations were difficult for all to attend (ASH 1975), and it was resolved that the next meeting should be held in Canberra, in fact every meeting of this society since 1975 has been held at a field location where all participants can be accommodated together, making the meetings of this society exceptional amongst scientific societies. It is amusing to note also that a motion was put to the 1975 meeting to raise the annual subscription from $2 to $5, a motion which was withdrawn after discussion.

Moving into the Cenozoic era

Gordon was afforded the opportunity to learn to fly in the early 1970s through his connection with Professor Harry Messel and their mutual interest in crocodilian research in the Northern Territory. It was a skill that was to affect his research interests for the rest of his working life. Not only did it allow him to commute to the Northern Territory, or turn up to the Olive Downs meeting at the last minute, but it opened up the opportunity to conduct aerial surveys of various animals across the vast Australian continent. His first papers involving aerial survey concentrated on crocodilian nesting sites (Magnusson *et al.* 1978, 1980), but he soon began a fruitful collaboration with Dr Graeme Caughley (Plate 10), then also on the academic staff in the Department of Zoology, surveying kangaroos across inland NSW. These surveys were extended to Queensland and South Australia, such that Gordon was flying transects across most of the eastern half of Australia annually. Gordon became interested in kangaroo population biology (Caughley and Grigg 1981, 1982; Short and Grigg 1982; Caughley *et al.* 1983), an interest which has continued to the present day (Table 1, Figure 2).

As always his students were keen to join in with his interests, and Eric eagerly accepted an invitation to assist Gordon and Graeme Caughley to count kangaroos from the air. It only took three nauseous transects before Graeme's toweling hat was offered to Eric, and a special landing was made to eject the offending student, and now malodorous hat. However, the opportunity was not wasted on Eric, who, years later at the North Coast Area Health Service, applied this intimate understanding of kangaroo counting methodology to develop the commonly used Child Activity Scanning Tool. This tool is used for reliable estimation of child physical activity levels in school playgrounds (Zask *et al.* 2001, 2003). Ironically, Eric is currently supervising a validation study of this tool by one of his PhD students.

Realising he had made rather a large evolutionary step from crocodiles to kangaroos, Gordon hastened to retrace his steps and, near the end of his time at the University of Sydney, filled this gap by launching a study into the thermal physiology of echidnas with Lyn Beard and Mike Augee (UNSW) (Grigg *et al.* 1989). Studies of echidnas were to continue into the 1990s and the new millenium (Table 1, Figure 2).

Gordon's journey through the geologic time scale at the University of Sydney was recognised by the award of a DSc in 1987 for his thesis "Oxygen supply, thermal relations and salinity relations in some lower vertebrates". It came to an end when he moved to Brisbane to take up the Chair of Zoology at The University of Queensland in 1989.

Conclusion

In these early times, Gordon attacked everything with enthusiasm, he was an inveterate explorer of places and ideas, and he led by example. He encouraged us, his students, to take all opportunities available, be independent thinkers and workers. He exposed us to broad ideas, big ideas and a range of techniques for studying several vertebrates, and passed on his wisdom over the campfire as well as at the laboratory bench. With this diverse training, we were well equipped to tackle a wide range of questions in the future. Jane's study of placentation in reptiles was the beginning of a long interest in reproductive biology and health. Her current work focuses on the complex mammalian placenta, although no longer with a physiological but rather a psychosocial focus. Eric applies the diverse zoological techniques learnt at the University of Sydney to a range of public health issues. Gill ran a comparative physiology laboratory at the University of NSW, with the confidence that vertebrates from fish to mammals could be studied to answer physiological questions. We feel that our own journey in geological history has been all the more fruitful because of its remarkable beginnings with Gordon at the helm (Appendix 1, photo 11).

Acknowledgements

Thanks to all the students and staff in the Department of Zoology at the University of Sydney in the 1970s for making the era memorable. Thank you to Leighton Llewellyn who constructed the 2 figures. Jane Thompson took the photo for Plate 8 and Gillian Courtice took the other photos. Thank you to Gordon for the PhD supervision, the adventures and the memories.

References

ASH 1975. Minutes of the eighth general meeting of the Australian Society of Herpetologists. *ASH Newsletter* No. **16**.

Barker, J. and Grigg, G.C. 1977. *A Field Guide to Australian Frogs*. Rigby Ltd., Adelaide.

Barker, J., Grigg, G.C. and Tyler, M.J. 1995. *A Field Guide to Australian Frogs*. Surrey Beatty and Sons, Sydney.

Boles, W.E., Longmore, N.W. and Thompson, M.C. 1994. A recent specimen of the Night Parrot *Geopsittacus occidentalis*. *Emu* **94**: 37-40.

Caughley, G.J. and Grigg, G.C. 1981. Surveys of the distribution and density of kangaroos in the Pastoral Zone of South Australia, and their bearing on the feasibility of aerial survey in large and remote areas. *Australian Wildlife Research* **8**:1-11.

Caughley, G.J. and Grigg, G.C. 1982. Numbers and distribution of kangaroos in the Queensland pastoral zone. *Australian Wildlife Research* **9**:365-71.

Caughley, G.J., Short, and Grigg, G.C. 1983. How many kangaroos? *Search* **14**:151-152.

Cogger, H.G., Cameron, E.E. and Cogger, H.M. 1983. *Zoological Catalogue of Australia. Volume 1. Amphibia and Reptilia*. Australian Government Publishing Service: Canberra.

Courtice, G.P. 1972. A taxonomic revision of the *Litoria aurea* complex (Anura: Hylidae). *BSc Hons thesis*, University of Sydney, Australia.

Courtice, G.P. 1978. Some aspects of respiration and its control in the Eastern Water Dragon, *Physignathus lesueurii* (Gray). *PhD thesis*, University of Sydney, Australia.

Courtice, G.P. 1980. Stimulation of carotid arterial chemoreceptors by hypoxia and hypercapnia in a lizard. *Proceedings of the International Union of Physiological Sciences* **14**: 362.

Courtice, G.P. 1981a. Respiration in the Eastern Water Dragon, *Physignathus lesueurii* (Agamidae). *Comparative Biochemistry and Physiology* **68A**: 429-436.

Courtice, G.P. 1981b. The effect of temperature on bimodal gas exchange and the respiratory exchange ratio in the Water Dragon, *Physignathus lesueurii*. *Comparative Biochemistry and Physiology* **68A**: 437-441.

Courtice, G.P. 1981c. Changes in skin perfusion in response to local changes in P_{C02} in a diving lizard, *Physignathus lesueurii*. *Comparative Biochemistry and Physiology* **69A**: 805-807.

Courtice, G.P. 1985. Effect of hypoxia on cardiac vagal action in a lizard *Physignathus lesueurii*, and its contribution to diving bradycardia. Pp. 373-377 in *Biology of Australasian Frogs and Reptiles*, edited by G. Grigg, R. Shine, and H. Ehmann, Surrey Beatty and Sons, Pty. Ltd., Sydney.

Courtice, G.P. and Grigg, G.C. 1975. A taxonomic revision of the *Litoria aurea* complex (Anura, Hylidae) in south-eastern Australia. *Australian Zoologist* **18**:149-163.

Garnett, S., Crowley, G., Duncan, R., Baker, N. and Doherty, P. 1993. Notes on Live Night Parrot Sightings in North-western Queensland. *Emu* **93**: 292-296.

Grigg, G.C. 1974. Respiratory properties of the blood of fish. Pp. 331-368 in *Chemical Zoology Volume VIII, Deuterostomians, Cyclostomes and Fishes*, edited by Florkin and Scheer. Academic Press, New York.

Grigg, G.C. and Alchin, J. 1976. The role of the cardiovascular system in thermoregulation of *Crocodylus johnstoni*. *Physiological Zoology* **49**:24-36.

Grigg, G.C. and Barker, J. 1973. Frog Calls of S.E. Australia. Audio Tape. University of Sydney.

Grigg, G.C., Beard, L.A. and Augee, M.G. 1989. Hibernation in a monotreme, the echidna *Tachyglossus aculeatus*. *Comparative Biochemistry and Physiology* **92A**:609-612.

Grigg, G.C., Shine, R. and Ehmann, H. 1985. *Biology of Australasian Frogs and Reptiles.* Surrey Beatty and Sons, Sydney.

Halliday, T.R. and Heyer, W.R. 1997. The case of the vanishing frogs. *Technology Review* **May/June 1997**: 56-63.

Kirshner, D.S. 1985. Buoyancy control in the estuarine crocodile, *Crocodylus porosus*: Schneider. *PhD thesis*. University of Sydney, Australia.

Magnusson, W., Grigg, G.C. and Taylor, J.A. 1978. An aerial survey of potential nesting areas of the Saltwater Crocodile (*Crocodylus porosus* Schneider) on the north coast of Arnhem Land, northern Australia. *Australian Wildlife Research* **5**:401-15.

Magnusson, W., Grigg, G.C. and Taylor, J.A. 1980. An aerial survey of potential nesting areas of *Crocodylus porosus* on the west coast of Cape York Peninsula. *Australian Wildlife Research* **7**:465-78.

Mahony, M. 1999. Review of the declines and disappearances within the bellfrog species group (*Litoria aurea* species group) in Australia. Pp. 81-93 in *Declines and Disappearances of Australian Frogs*, edited by A. Campbell. Environment Australia, Canberra.

Pepperell, J. and Grigg, G.C. 1974. A labyrinthodont trackway from the mid-Triassic near Sydney, New South Wales. *Proceedings of the Linnaean Society of NSW* **99**:54-6.

Short, J. and Grigg, G.C. 1982. The abundance of kangaroos in suboptimal habitats wheat, intensive pastoral, mallee. *Australian Wildlife Research* **9**:221-227.

Taplin, L.E. 1982. Osmoregulation in *Crocodylus porosus*. *PhD thesis*. University of Sydney, Australia.

Taplin, L.E. and Grigg, G.C. 1981. Salt glands in the tongue of the Estuarine Crocodile. *Science* **212**:1045-7.

Taylor, J. 1977. The foods and feeding habits of sub-adult *Crocodylus porosus*, Schneider, in Northern Australia (Crocodilia:Reptilia). *MSc thesis*, University of Sydney, Australia.

Thomson, S.A., Littlejohn, M.J., Robinson, W.A. and Osborne, W.S. 1996. Taxonomy of the *Litoria aurea* complex: a re-evaluation of the Southern Tableland populations of the Australian Capital Territory and New South Wales. *Australian Zoologist* **30**: 158-169.

Thompson, J. 1977. Embryo-maternal relationships in a viviparous lizard *Sphenomorphus quoyii* (Dumeril and Bibron). *PhD thesis*, University of Sydney, Australia.

Thompson, J. 1981. A study of the sources of nutrients for embryonic development in a viviparous lizard, *Sphenomorphus quoyii. Comparative Biochemistry and Physiology* **70A**: 508-518.

Thompson, J. 1982. Uptake of inorganic ions from the maternal circulation during development of the embryo of a viviparous lizard, *Sphenomorphus quoyii. Comparative Biochemistry and Physiology* **71A**: 107-112.

van Beurden, E. 1977. Water and energy relations of the Australian Water-holding Frog *Cyclorana platycephalus*. *PhD thesis*. University of Sydney, Australia.

van Beurden, E. 1979. Gamete development in relation to season, moisture, energy reserve, and size in the Australian Water-holding Frog, *Cyclorana platycephalus*. *Herpetologica* **35**: 4: 370-374.

van Beurden, E. 1980. Energy metabolism of dormant Australian Water-Holding Frogs (*Cyclorana platycephalus*) *Copeia*, **1980**: 787-799.

van Beurden, E. 1982. Desert adaptations of *Cyclorana platycephalus*: a holistic approach to desert-adaptation in frogs. Pp. 235-240 in *Evolution of the Flora and Fauna of Arid Australia* edited by W.R. Barker and P.M. Greenslade. Peacock Publications, South Australia.

van Beurden, E. 1984. Survival strategies of the Australian Water-holding Frog, *Cyclorana platycephalus*. Pp. 223-234 in *Arid Australia* edited by H.G. Cogger and E.E. Cameron. Australian Museum, Sydney.

Wright, J.C. 1985. Oxygen consumption during voluntary undisturbed diving in the Saltwater Crocodile, *Crocodylus porosus*. Pp. 423-429 in *Biology of Australasian Frogs and Reptiles*, edited by G. Grigg, R. Shine, and H. Ehmann, Surrey Beatty and Sons, Pty. Ltd., Sydney.

Wright, J.C., Grigg, G.C. and Franklin, C.E. 1992. Redistribution of air within the lungs may potentiate "fright" bradycardia in submerged crocodiles (*Crocodylus porosus*). *Comparative Biochemistry and Physiology* **102A**: 33-36.

Zask, A., van Beurden, E., Barnett, L., Brooks, L.O. and Dietrich, U.C. 2001. Active School Playgrounds—Myth or Reality? Results of the "Move It Groove It" Project. *Preventive Medicine*, **33**: 402-408.

Zask, A., van Beurden, E., Barnett, L., Beard, J. and Dietrich, U.C. 2003. *'Move It, Groove It - Physical Activity in Primary Schools' Summary Report.* NSW Department of Health. ISBN: 0 7347 3395 X.

APPENDIX I

1. University of Sydney, 1972.

APPENDIX I

2. John Barker was a technical officer in the Zoology Department, University of Sydney in the 1970s and taught us all a great deal about frog identification and biology. He died in 1995, in the same year the new edition of A Field Guide to Australian Frogs was published (Barker, Grigg and Tyler 1995).

Exploration of frog habitat in south eastern Australia.

3a. 1972, Gordon Grigg recording the call of *Philoria frosti* on Mount Baw Baw, Victoria.

3b. 1974, Breakfast at Ulong Station after a long wet night of searching for *Litoria aurea ulongensis,* a subspecies which was included in *Litoria aurea* (Courtice and Grigg 1975). From left: Eric van Beurden, Christine Lehmann, Janet Taylor and Bill Magnusson.

3c. 1972, Typical habitat of *Litoria aurea,* Howe's Swamp, Putty Road, NSW.

3d. 1972, Searching for *Litoria raniformis* near Narrandera, NSW.

3e. 1972, Leighton Llewellyn and Gordon electro-fishing for frogs near Guyra, NSW. It didn't work!

3f. 1972, Leighton Llewellyn and Gordon replacing the habitat structure after searching for *L. flavipunctata* near Guyra, NSW.

4a. Macquarie Marshes in 1972, north of Warren NSW.

4b. Drying out after a very wet night amongst the desert frogs.

Simpson Desert expedition, 1973. Setting up camp at Plenty Downs.

5a. Setting up camp at Plenty Downs abandoned homestead.

5b. Leighton Llewellyn and student examine bird wing in makeshift laboratory at Plenty Downs.

APPENDIX I

5c. One of the bores on the Plenty River.

5d. Cameron and Carmel Chalmers, owners of Plenty Downs, on their property, Atula Station.

5e. Gill traveling with a better view of the desert

5f. Eric – ever hopeful.

Simpson Desert expedition, 1973. Biologists at work.

6a. Searching for desert frogs, in entirely the wrong location! A lot of chiefs watching, Gordon centre right.

6b. Measuring the temperature inside a termite mound.

6c. A lot of interest in a dung beetle.

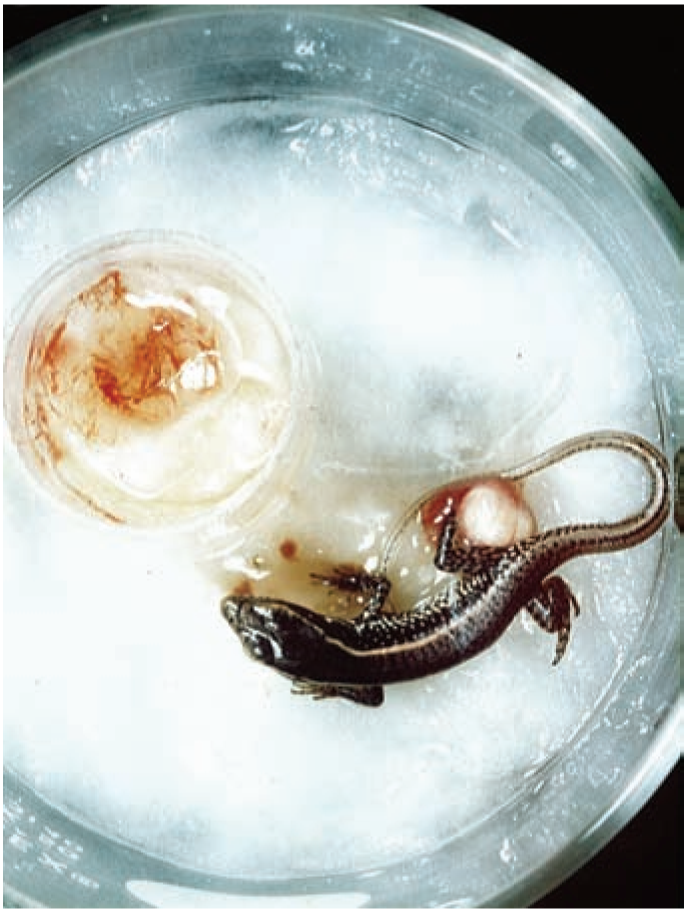
6d. Eric and a student from Macquarie University set mammal traps.

6e. Capture of Brown Hawk, Leighton Llewellyn. Alas, not the Night Parrot.

6f. The biologists and geologists met in the Hart's Ranges.

7a. Members of the academic staff in the Department of Zoology, led by Gordon to Mootwingee, north of Broken Hill, Easter 1973. From left, Gordon, Patsy Armati-Gulson, Anne Underwood, Tony Underwood.

7b. Rock carving at Mootwingee. Gordon and Jan had a long term interest in Aboriginal rock art.



8. A Water Skink was successfully hatched *in vitro*, demonstrating the independence of the embryo from the mother (Thompson 1977, 1981).

APPENDIX I

Australian Society of Herpetologists meeting at Olive Downs, Sturt National Park, NSW, Easter 1975.

9a. Shearers quarters, Olive Downs where meeting was held.

9b. The students set off days before, lugging all the equipment. Eric and Jane eat lunch at Broken Hill.

9c. Jane fills up with petrol at Tibooburra.

9d. Gordon lands on the Olive Downs airstrip.

9e. Gordon and Rob Jenkins mull over the program.

9f. Hal Heatwole, Emmy Dankers, Rick Longmore and others wait for dinner.

10. The late Graeme Caughley.

11. Brisbane 2007, survivors of the Paleozoic era. From left Lyn Beard, Jane Thompson, Gordon Grigg, Eric van Beurden, Gillian Courtice, Jan Grigg.